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EDITED BY DOROTHY E. ROSE

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RECENT DEVELOPMENTS IN THE CHEMISTRY OF THE RARE EARTH GROUP*

BY

B. SMITH HOPKINS

University of Illinois, Urbana, Illinois

One of the most puzzling problems which confronts this generation of chemists is furnished by the rare earth group. Here is a collection of chemical elements which occupies a unique position in the family of chemical individuals. With properties so similar that they are invariably found in intimate association in nature, making the problem of their separation a task of heroic proportions, they present a challenge to the best efforts of the most courageous. We are far from a complete solution of this puzzle at the present time. Advancement must neces-

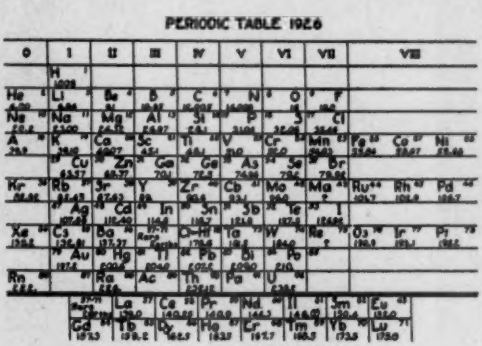

FIG. 1.

sarily be slow in a problem so intricate. But progress must continue, even though the immediate rewards seem to be meagre. There seems to be a definitely growing interest in the scientific relationship of the group. We should like to know more about each member in respect to such items as atomic structure, magnetic forces, and atomic radii. We would like to know more about the relationship of each element to the other rare earths and to all the other elements. It is by no means impossible that when we understand the members of this group better, we shall find in this knowledge the key which will unlock whole storehouses of information concerning our more important commercial elements.

* Address of the Retiring President, read before the General Session, May 3, 1934.

One of the most puzzling questions concerning the rare earth group is its relationship to the periodic table. Many suggestions have been made for the placing of this group in order to show its relationship to the rest of the elements. Figure 1 shows a common method

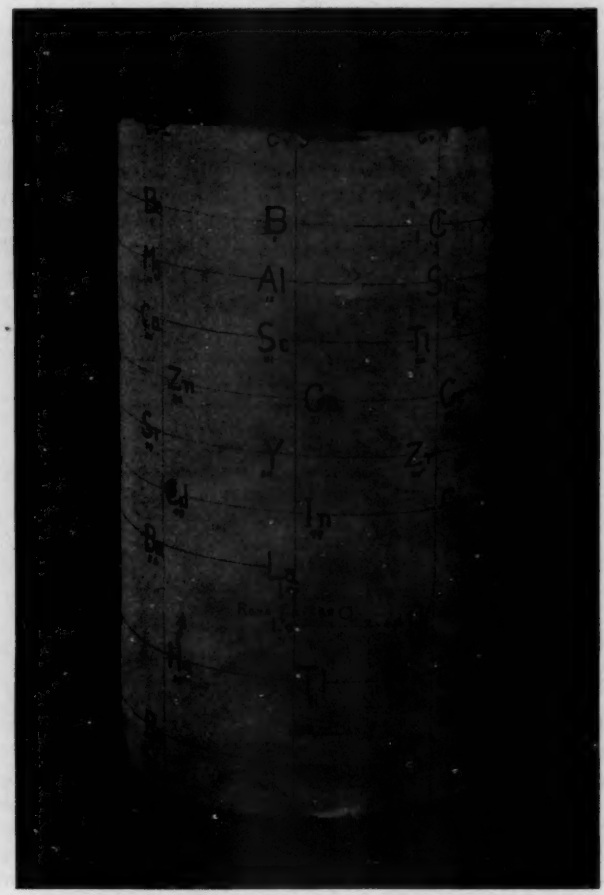

Fig. 2. Periodic table in cylindrical form.

of locating this group on a flat surface arrangement of the table. It emphasizes the fact that the rare earth elements have similar properties with a characteristic valence of three. Each could with perfect propriety be placed in the third group between barium (Group II) and

hafnium (Group IV). Rather than attempt to crowd the 15 elements into this one space, many authors prefer to indicate that the entire group belongs here and then append a supplementary table showing each individual element in its proper sequence.

Figure 2 shows a similar plan applied to a cylindrical arrangement of the table. In Figure 3 there is an interesting helical plan, with all the elements of the rare earth group crowded into the one space by means of an accordion-like extension. This gives an unusually appropriate setting for the group. Figure 4 shows the sequence of the

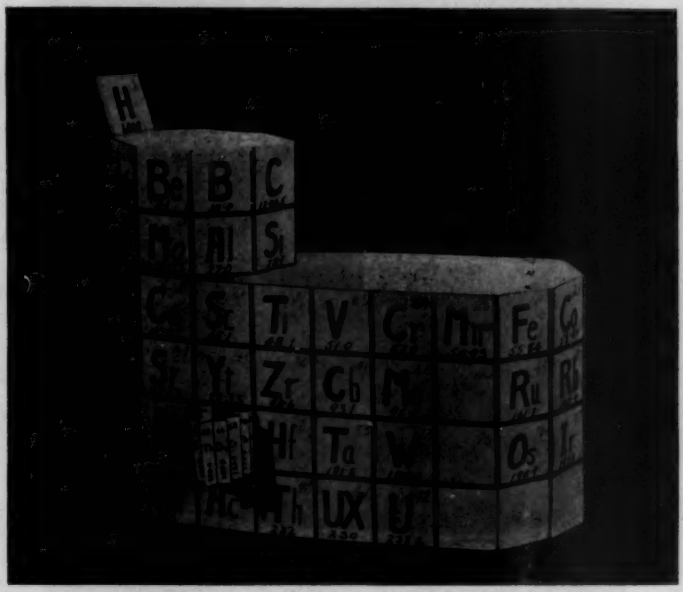

Fig. 3. Periodic table in tower form, after M. Courtines.

elements arranged spirally around a globe. Hydrogen is at the north pole and the short series are conveniently arranged near the pole. As the sequence approaches the equator the longer series fall into position normally. The rare earth group fills the equitorial belt without crowding. While the space adjustments in this arrangement are clever, it brings the individual members of the group into quite unnatural positions with respect to other elements. For example, this arrangement makes it necessary to interpose some members of the rare earth group between such closely related elements as zirconium and hafnium, columbium and tantalum, or molybdenum and tungsten, while other rare earths fall into unnatural positions with respect to the platinum metals

and the alkali group. Similar objections can be raised to most of the arrangements in which an attempt is made to give each member of the rare earth group a separate space in the periodic table.

As the scientific interest in the rare earth group increases there is certain to be a greatly increased importance attached to the amount

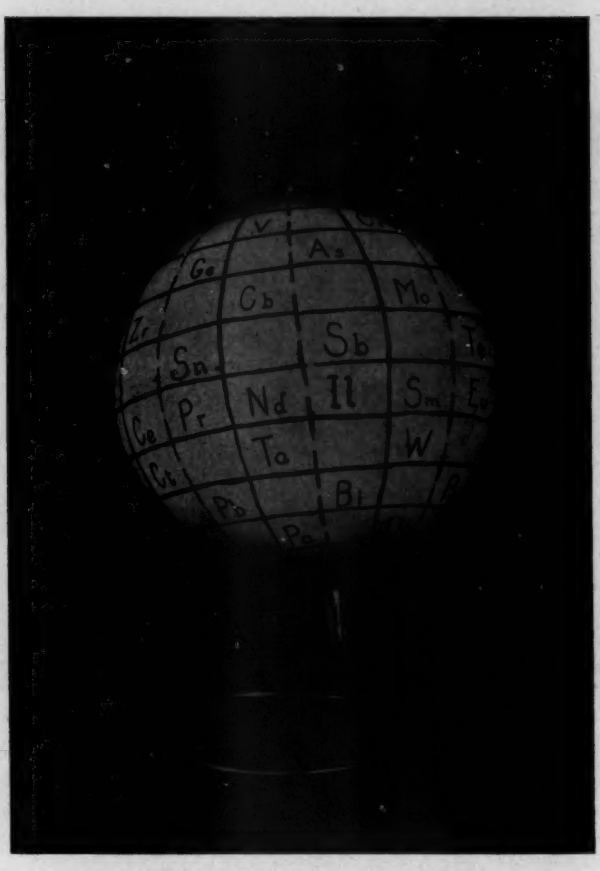

Fig. 4. Periodic table in spherical form.

of material available for the study of each member of the group. Accordingly there is increasing interest not only in the deposits of rare earth minerals themselves but also in the relative abundance of each individual element. Table 1 gives a tabulation which is based on various estimates. The figures in the third vertical column show the average per cent of each individual element in the rare earth content of

all available rare earth ores[1]. It is interesting to note that cerium, the most abundant member, makes up nearly one-third of the entire group, while illinium, the rarest member, is not more abundant than 0.02 of one per cent. When these values are plotted against atomic numbers as in Figure 5 we see graphically that the even numbered members of the group are always more abundant than the neighboring odd numbered members. This interesting fact suggests that there must be some reason connected with the structure of these atoms which

TABLE 1.—*Abundance of the rare earths*

Atomic number	Symbol	Per cent of the rare earth group	Per cent in the earth's crust
57	La	7	0.00007
58	Ce	31	0.00031
59	Pr	5	0.00005
60	Nd	18	0.00018
61	Il	0.02	0.0000002
62	Sm	7	0.00007
63	Eu	0.2	0.000002
64	Gd	7	0.00007
65	Tb	1	0.00001
66	Dy	7	0.00007
67	Ho	1.2	0.000012
68	Er	6	0.00006
69	Tn	1	0.00001
70	Yb	7	0.00007
71	Lu	1.5	0.000015
		99.92	

gives greater stability to the groupings with an even number of electrons. At present our information does not furnish a satisfactory explanation.

The last vertical column in Table 1 shows the fraction of the earth's crust that is composed of the rare earth group. These figures are based on Dr. H. S. Washington's statement that the entire group comprises about 0.001 per cent of the earth's crust. While the percentage of the most abundant members of the group is extremely small it is to be noted that cerium is more common than cadmium, tin, mercury, antimony, molybdenum, silver, tungsten, bismuth, gold or platinum. Likewise the least abundant member of the group, illinium,

[1] These figures are furnished by Goldschmidt and Thomassen, Videnskapsselskafets skrifter I Matemat-Naturv. Klasse, Kristiana 1924, No. 5, p. 49. The estimate for illinium is based on the statement of Dr. G. R. Sherwood that illinium in monazite is approximately one-tenth as abundant as europium.

which makes up only about two ten-millionths of one per cent of the earth's crust, is still presumably a thousand times more abundant than radium, whose commercial importance is considerable. Therefore it seems safe to conclude that if any single member of the rare earth group is shown to possess striking individual properties of value, the scarcity of the element will not be an insurmountable obstacle in the pathway of its commercial development.

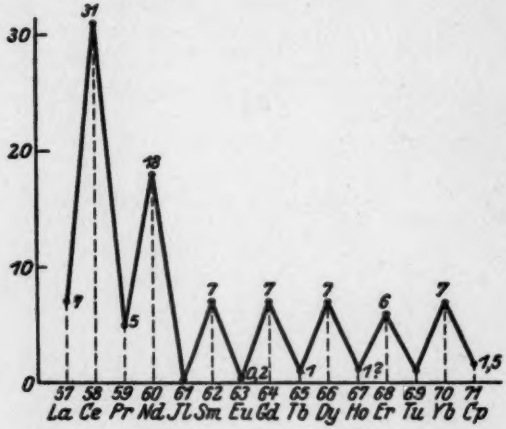

FIG. 5. Abundance of the rare earths against atomic numbers.

A study of the atomic structure of the members of the rare earth group (Table 2), shows the slight differences between succeeding members. For comparison there are also shown the structures of cesium and barium immediately preceeding the rare earths as well as hafnium and tantalum, the first elements following the group. It is to be noted that the valence, of the rare earths remains essentially constant and that the only structural differences come from the addition of successive electrons in the 4_4 shell. With such strikingly similar structures, it is natural to expect that these atoms will have similar properties and that their separations from one another will be extremely difficult.

Formerly the valence of the rare earth group was by definitions limited to three, and any member like cerium which showed a valence of four was eliminated as though it were an intruder. While the rare earths are still to be regarded as characteristically trivalent in nature, recent studies have shown that both higher and lower valences exist.

Figure 6 shows these anomalous valences. Quadrivalent compounds of cerium are well known and important. Praseodymium is also quadrivalent, possibly occasionally pentavalent. Quadrivalent compounds of terbium have recently been shown to exist. Since cerium, praseodymium and terbium may be oxidized, it might be logical to expect that dysprosium would also show a higher valence, although no such compounds have yet been reported.

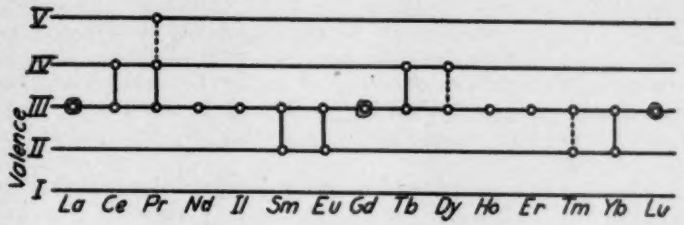

FIG. 6. Valence of the rare earths.

TABLE 2.—*Atomic structures of the elements*

Atomic number	K	L		M			N				O					P	
	1_1	2_1	2_2	3_1	3_2	3_3	4_1	4_2	4_3	4_4	5_1	5_2	5_3	5_4	5_5	6_1	6_2
Cs 55	2	2	6	2	6	10	2	6	10	0	2	6	0	0	0	1	...
Ba 56	2	2	6	2	6	10	2	6	10	0	2	6	0	0	0	2	...
La 57	2	2	6	2	6	10	2	6	10	0	2	6	1	0	0	2	...
Ce 58	2	2	6	2	6	10	2	6	10	1	2	6	1	0	0	2	...
Pr 59	2	2	6	2	6	10	2	6	10	2	2	6	1	0	0	2	...
Nd 60	2	2	6	2	6	10	2	6	10	3	2	6	1	0	0	2	...
Il 61	2	2	6	2	6	10	2	6	10	4	2	6	1	0	0	2	...
Sa 62	2	2	6	2	6	10	2	6	10	5	2	6	1	0	0	2	...
Eu 63	2	2	6	2	6	10	2	6	10	6	2	6	1	0	0	2	...
Gd 64	2	2	6	2	6	10	2	6	10	7	2	6	1	0	0	2	...
Tb 65	2	2	6	2	6	10	2	6	10	8	2	6	1	0	0	2	...
Ds 66	2	2	6	2	6	10	2	6	10	9	2	6	1	0	0	2	...
Ho 67	2	2	6	2	6	10	2	6	10	10	2	6	1	0	0	2	...
Er 68	2	2	6	2	6	10	2	6	10	11	2	6	1	0	0	2	...
Tu 69	2	2	6	2	6	10	2	6	10	12	2	6	1	0	0	2	...
Yb 70	2	2	6	2	6	10	2	6	10	13	2	6	1	0	0	2	...
Lu 71	2	2	6	2	6	10	2	6	10	14	2	6	1	0	0	2	...
Hf 72	2	2	6	2	6	10	2	6	10	14	2	6	2	0	0	2	...
Ta 73	2	2	6	2	6	10	2	6	10	14	2	6	3	0	0	2	...

In similar manner samarium, europium and ytterbium may be induced to show a valence of two by electrolytic reduction. Since terbium

is the seventh element from cerium and ytterbium is the seventh element after europium, it might be assumed that these anomalous valences occur at uniform distances. If this reasoning is correct. then thullium, the seventh element after samarium should form bivalent compounds. While none have yet been prepared, efforts are being made to find the conditions under which thullium salts will be reduced. Here again is a peculiar situation whose explanation requires an extended study of atomic structures.

These irregular valences are becoming useful in the difficult task of separation. Cerium has long been separated effectively from its neighbors in a single step consisting of boiling the oxidized solution. Ceric salts are easily hydrolyzed and precipitated as a basic salt. Similar methods are being sought for the separation of praseodymium, terbium and possibly dysprosium.

When the rare earth elements become bivalent the solubilities of their salts are like those of barium. Accordingly when europium and ytterbium salts are subjected to cathodic reduction in the presence of the sulfate ion, difficultly soluble $EuSO_4$ and $YbSO_4$ are precipitated. These separations from simple mixtures are nearly quantitative and they mark a distinct advance in rare earth chemistry, because both of these elements have up to the present been almost impossible to isolate. If by modifying the conditions we could devise a method for the isolation of samarium and thullium the work of the rare earth chemist would be vastly simplified.

All metals of the rare earth group are fairly active, but their hydroxides do not furnish a high concentration of hydroxyl ion because of their insolubility. There are considerable differences in the basicity of the various members of the group. Table 3 shows an attempt to reduce these values to a ratio by using the basicity of $Y(OH)_3$ as unity. It is to be noted that lanthanum is much the most basic member of the group and it is safe to say that $La(OH)_3$ is the strongest trivalent base that we know. It is also important to notice that the ratios between these values are relatively large, at least in some cases. For example lanthanum is 11 times as basic as praseodymium while neodymium is nearly 6 times as basic as samarium.

TABLE 3

Atomic number	57	59	60	62	64	39	66
Element	La	Pr	Nd	Sm	Gd	Y	Dy
Basicity ratio.....	1300	80	47	8	3.4	1	0.5

Some of our most useful methods of separation are based upon these differences in basicity. As a consequence the order of decreasing basicity becomes a matter of great importance. In Table 4 we have a tabulation of the order as it is reported by various workers, using

various methods and conditions. It is evident that there is little question concerning the order of decreasing basicity in Zones 1 and 3, but in the center the order of basicity is in much doubt. This situation undoubtedly results from the fact that in the center of the group there are less differences in basicity than at either end. Because of the importance of accurate information upon the order of basicity we have undertaken to measure these values for the entire group, using a common method throughout. The hydrolysis of the rare earth nitrite was selected as a suitable method because conditions can be accurately controlled and the method is easily applied to all parts of the group. As

TABLE 4

	A	B	C	D	E	F	G
Zone 1	La +++ Ce Pr Nd Y	La +++ Ce Pr Nd Y		La +++ Ce Pr Nd	La Pr Nd Y	Dy La Pr Nd Y	La Pr Nd Y
Zone 2	Sm Eu Gd	Eu Gd Sm	Gd Sm	Sm Eu Gd	Gd Sm	Sm	Sm Gd
Zone 3	Tb Dy Ho Er Tm Yb Lu Sc +++ Ce	Tb Dy Ho Er Tm Yb Lu Sc	Tb	Tb Dy Y Er Tm Yb	Tb Dy Er	Tb	Tb Dy

usually applied this method consists in adding $NaNO_2$ to a neutral solution of the rare earth nitrates and boiling until those elements which are the least basic are precipitated while the elements of greater basicity remain in solution. By filtering off the precipitate there is accomplished a partial separation of the mixture of salts in accordance with the relative basicity of the elements present. We found that the differences in basicity between illinium, samarium, europium and gadolinium, the elements in zone 2, were so slight that the usual methods of procedure were not adequate. Consequently there was devised a method of fractionation by which these slight differences were magnified. Figure 7 shows diagramatically the method used. The solid arrows indi-

cate the way in which the precipitates were combined and the broken arrows the path of the mother liquor. In this way slight differences in basicity were intensified and actual separations accomplished. As a result of this work it has been established that the order of decreasing basicity throughout the rare earth group is exactly the order of increasing atomic number. If yttrium (No. 39) is included in the rare earth group it would form an exception to this statement since its basicity falls between illinium (No. 61) and samarium (No. 62).

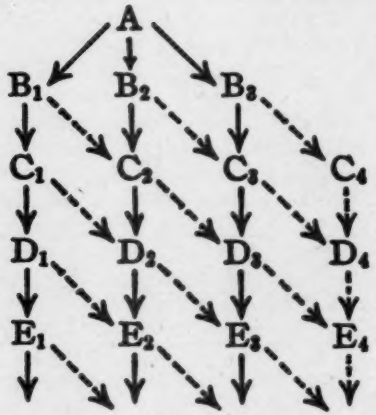

FIG. 7. Plan showing steps in the concentration of the rare earths by intensive basicity method.

The concentration of illinium by methods of fractional crystallization is well nigh impossible because this extremely rare element is always associated with other elements which are vastly more abundant and whose salts differ but slightly in solubility. By applying this new method of intensifying the differences in basicity we have greatly speeded up the concentration of illinium. In Figure 8 the per cent of illinium is plotted against the number of fractionations by the two methods. It is seen that 25 basicity fractionations effect about twice as great a concentration as is accomplished by 2000 fractionations of the double magnesium nitrates.

The metals of the rare earth group are interesting from their magnetic behaviors. When carefully measured it is found that their magnetic susceptibilities show greater variation than can be detected with regard to any other property. The magnetic susceptibility of mixtures is strictly additive. As a consequence in simple mixtures this property furnishes the most accurate means of analysis that we have.

An accuracy of 0.1 per cent has been claimed for mixtures of the compounds of two elements. Figure 9 shows the coefficient of magnetization plotted against the atomic numbers.

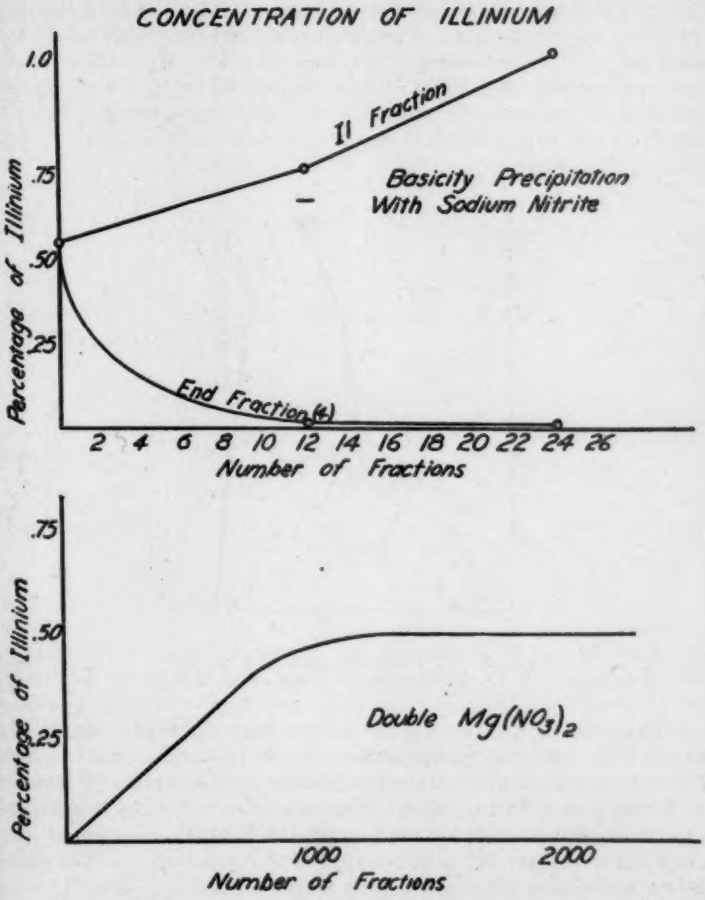

FIG. 8. Fractional crystallization increases the illinium content rapidly at first, but it soon becomes ineffective (lower curve). The upper curve shows that 24 fractionations by intensive basicity precipitation double the illinium content.

A subject of increasing interest in the rare earth field has to do with their utilization. Extensive uses are now made of mixtures of

this group and great interest has lately developed in regard to the commercial applications of some of the more abundant members of the group. It is obvious that uses for the pure forms of the less abundant members of the group will be much more difficult to produce. One of the most interesting developments of recent months has been the utilization of the octohydrate of gadolinium sulfate for the production of extremely low temperatures. This work is noteworthy because of the near approach to the absolute zero, because it uses an entirely new principle in achieving this end, and because it uses a single member of the rare earth group which is relatively rare in a high state of purity for a specific purpose.

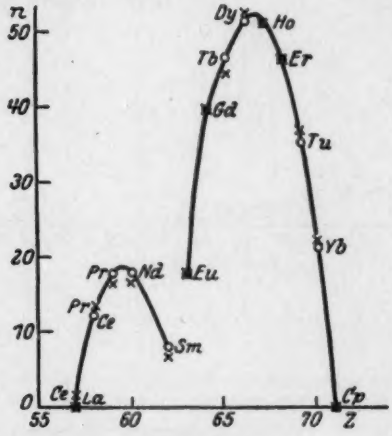

FIG. 9. Magnetic susceptibility plotted against atomic numbers.

When $Gd_2(SO_4)_3.8H_2O$ is placed in a magnetic field it transforms some of the magnetic energy into heat and becomes warm. Under ordinary conditions the temperature change is not great. If however the octohydrate is first cooled to the temperature of boiling helium and a magnetic field of 20,000 gauss is used, the thermal transition is relatively large. Figure 10 shows an apparatus for this work. The gadolinium material is placed in a tube suspended from a balance. This tube is placed in a container which is filled with gaseous helium at low pressure, and surrounded by liquid helium. The system is isolated from external heat by two concentrically placed Dewar tubes. When a powerful field is applied to the rare earth material it becomes warm and imparts part of its heat to the helium gas. If this is now pumped

off and the magnetic field removed, the resulting temperature must be lower than the initial temperature. This method has yielded temperatures within 0.18° C. of the absolute zero, the nearest approach to that mythical point yet obtained. It is interesting to speculate as to what results might be obtained if alternate magnetizations and demagnetizations were applied in cycle fashion.

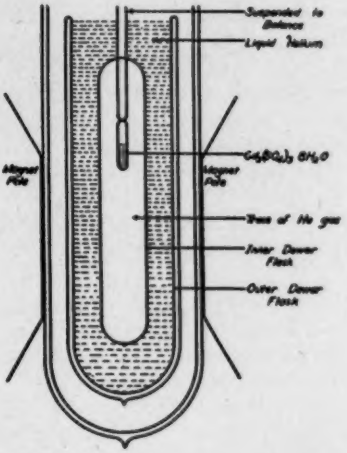

FIG. 10. Diagram of the apparatus used in the production of extremely low temperatures by the use of rare earth salts.

Similar Results have been obtained with the use of $Ce_2(SO_4)_3 .8H_2O$. It is quite probable that other members of the group may show similar properties. We should like to know what peculiarities of atomic and molecular structures make this behavior possible. We would also like to learn whether the pure salts are needed for the display of this phenomenon or whether a mixture of rare earth salts would be equally effective.

THE SIGNIFICANCE OF THE CONSERVATION OF LAND RESOURCES

BY

H. W. MUMFORD[1]

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In these days of much publicized apparent surpluses of some farm products it may seem inappropriate to even suggest, let alone discuss, the significance of the conservation of land resources. On the contrary, such a discussion seems to me to be all the more necessary because of the likelihood of the public in general obtaining erroneous ideas concerning the real situation. It is obvious that it will be quite impossible in the brief time at my disposal to give this important subject adequate consideration.

I shall be forced to make some rather sweeping statements without the opportunity of fortifying these statements with adequate supporting evidence. I must ask my hearers, therefore, to be charitable enough to accept such statements as may be made on the assumption that there is in existence sufficient supporting evidence to warrant them.

There are a few general propositions which may be briefly, and I trust profitably, discussed. They are:

1) That there is not a surplus of fertile land suitable for cropping purposes;

2) that through the processes of nature and the ravages of man, the extent and quality of these lands are rapidly declining;

3) that in the main good lands are perhaps the most valuable basic natural resource that this country, and particularly this State, possesses;

4) that methods have been developed through investigation and research whereby these good lands may be so utilized that they will remain indefinitely a continuing source of wealth; and

5) that the trend is strongly toward depreciation and waste of our land resources and that unless there is a rather speedy change in our practice relating to land use, we shall bequeath to our descendants an unwelcome heritage.

No surplus of fertile lands.—It is generally recognized that the margin of profit in farming under normal conditions is relatively small. Obviously, the less fertile the land, the smaller the margin of profit. The areas of fertile land are relatively small.

[1] This paper was read for H. W. Mumford by C. L. Stewart, College of Agriculture, University of Illinois.

The processes of nature and the ravages of man are rapidly reducing the extent of such land.—Let me remind you that there was a time, and not so many years ago, when it was mistakenly believed that the fertility of Illinois soils was so great that it was inexhaustible. Fortunately, the State has been saved the disaster that would have been inevitable had this mistaken belief prevailed for long. The Experiment Station of the University of Illinois has shown that far from being inexhaustible, the fertility of Illinois soils is rapidly destroyed by unbalanced cropping systems and by erosion. When we think of soil conservation, it is well to recall, too, the report of scientists with respect to the havoc brought by soil erosion in Illinois and throughout the Nation. Their findings show that erosion alone is washing away the farm fields of the United States at the rate of 3 billion tons of soil material a year, that there are in this country 35 million acres of what was once mostly good land which is now waste in so far as crop use is concerned because its top soil has been washed away by erosion. In some systems of faulty cropping, as in straight corn farming, the 7 inches of top soil on a slope as slight as 4 per cent can be destroyed in as short a time as 24 years. Repairing soil damage as serious as this requires between 2,000 and 3,000 years, because it takes nature about 400 years to build a single inch of productive, top soil from raw sub-soil clay.

In the midst of our seeming abundance, it is well to recall that history has recorded how vast tracts of land already have had to be abandoned because they were so badly eroded and otherwise so mistreated that they would no longer support life. If the final pages of history do not record the abandonment of vast additional tracts and an ever-increasing threat of a food supply shortage, it will be because of the type of service which the University of Illinois and similar institutions elsewhere are rendering in soil conservation.

These are times when national and international plans for agriculture are being much discussed. No matter what policy is adopted, if the soils of our farms are not cared for and conserved they will become impoverished, and a successful agriculture and a prosperous nation can not be built on impoverished soils.

From the soil fertility viewpoint, the history of American agriculture to date has been one of exploitation. Several years ago a point was passed unobserved by the general public and by farmers themselves, when further exploitation of the land meant exploitation of the people on the land. I am not blaming farmers for exploiting the land. Neither am I blaming other groups for exploiting the farmers, nor the farmers for permitting themselves to be exploited. Much of this has been more or less unconscious. Only where it has been conscious and

preventable is it inexcusable. It is not my purpose to attempt to fix the blame or responsibility. It is much more important to recognize the fact and leave to agricultural education and research the determination of the extent and effect of these conditions, and the methods of ameliorating them. The exploitation of the soil comes mainly from three groups: first, those efficient and intelligent producers who wilfully neglect the fertility of their soils for the sake of immediate gain; second, those who are inefficient producers and either know no better, or knowing, are too indifferent to care; and third, those who care and know how, but can not figure how they can maintain the fertility of the soils of their farms and survive financially. Perhaps if we should attempt to classify farmers with reference to these groups, we might learn something of real value.

A very practical hindrance to the general adoption of programs of soil maintenance is the fact that as long as fertile lands exist here or elsewhere, there will be plenty of men who will exploit them. As long as men exploit them, the products of such lands will come into competition with the products of farms operated with the high purpose of husbanding the resources of the land for posterity.

Good lands, the most valuable basic natural resource of the State. They may be conserved indefinitely as a continuing source of wealth. So far as the future of Illinois is concerned, there is no more valuable and enduring asset than the 30½ million acres in its farms, which comprise 85.6 per cent of its land. This natively fertile soil is perhaps the one major natural resource of the State which may be continued unimpaired for future generations by the application of knowledge which has been and can be worked out through investigation and research.

The most striking evidence of these principles has been obtained on the Morrow plots, America's oldest soil experimental plots, located on the University grounds at Urbana. Three different cropping systems have been practiced uninterruptedly for 57 years, and three soil treatment systems have been practiced for 29 years.

Continuous corn culture, representing the old belief that the fertility of Illinois soils is inexhaustible, has so undermined the land that the yield of corn has dropped to less than 20 bushels an acre. In contrast, a system of crop rotation combined with simple soil treatment, has maintained and built up the fertility of the soil to the point where it is yielding approximately 70 bushels of corn an acre.

The soil on the different plots was all equal when the experiment started 57 years ago. Today, on the basis of profitable crop production, the land on the plot where a crop rotation of corn, oats, and clover has been combined with simple soil treatment is worth 4½ times as much as the land where corn has been grown continuously without treatment.

It is worth twice as much as the land where continuous corn has been grown with simple soil treatment. It is worth 2⅓ times as much as the land where an inferior rotation of corn and oats has been practiced without soil treatment. It is worth 1 1/5 times as much as the land where the corn and oats rotation has been combined with simple soil treatment. It is worth 1⅓ times as much as the land where a rotation of corn, oats, and clover has been practiced without soil treatment.

Trend toward depreciation and waste.—Ex-Governor Lowden, reccognized as a thoughtful student of agriculture, in a published interview, is quoted as making some observations that may well form the basis for serious deliberation. In speaking of the tremendous loss of fertility in the Mississippi valley from erosion, he asks, "How long can the land stand this? - - - And while Nature is thus hammering away at our land, we, ourselves, go on speeding up the process of destruction by incessant cropping."

This important question is a challenge to our present generation. I do not wish to leave the impression that nothing is being done to change the trend. As a matter of fact, at no time in the history of our country have well-informed people been more concious of the need for more attention being given to conservation of our land resources, and it is an encouraging sign.

The authorities following me on this program will presumably bring out more clearly and definitely some of the matters I have but briefly referred to here. The National Government is attacking this problem most vigorously, particularly from the standpoint of submarginal lands and the attempt to crystalize public sentiment on the disastrous facts of erosion and the possibilities of its intelligent control. Such constructive policies should be aided in every proper way by scientific societies of this nature.

May I quote here, in closing, from Liberty Hyde Bailey's *The Holy Earth:*

"So BOUNTIFUL hath been the earth and so securely have we drawn from it our substance, that we have taken it all for granted as if it were only a gift, and with little care or conscious thought of the consequences of our use of it; nor have we very much considered the essential relation that we bear to it as living parts in the vast creation. - - - - Most of our difficulty with the earth lies in the effort to do what perhaps ought not to be done. Not even all the land is fit to be farmed. A good part of agriculture is to learn how to adapt one's work to nature, to fit the crop-scheme to the climate and to the soil and the facilities. To live in right relation with his natural conditions is one of the first lessons that a wise farmer or any other wise man learns. We are at pains to stress the importance of conduct; very well: conduct toward the earth is an essential part of it."

CLASSIFICATION OF ILLINOIS LANDS

BY

R. S. SMITH

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"The shock of the depression has at last awakened us to a new attitude. We no longer regard land as land alone; we regard it as one of the central and controlling elements in our whole national economy. More than that, we realize that upon the manner and character of its use may depend the welfare, not only of our descendents, but of ourselves."—Rexford G. Tugwell, Assistant Secretary of Agriculture.

The widespread interest in land use noted by Doctor Tugwell and the more recently developed agitation for planned land use and removal of less productive lands from production has focussed attention upon the need for land classification.

The approach to the problems of land classification varies somewhat with the training and experience of the one proposing classification. It is proposed in this paper that any classification of land for the purposes of land use should be based on the adaptation, producing capacity, and the capacity for response to fertilizer treatment of the soils making up what we commonly speak of as the land.

Land, as we use the term, comprises the layer of unconsolidated material which more or less continuously mantles the earth's surface and which varies in its adaptation, in its capacity to produce plants, and in its capacity to respond to treatments designed to increase the quantity, or quality of its products or to change its natural adaptation.

If this concept is sound it follows that land is not the same thruout its extent and that, therefore, it must be divided into units of some sort if it is to be understood. The kind of unit will depend on the purpose for which the division is made.

Our task then in developing a land classification seems to involve the creation of soil units. After the creation of these soil units, it is necessary to become familiar with the properties of each unit and then to combine the units into groups which will satisfy our requirements. This sounds simple enough but difficulties arise which only time and an immense amount of work can iron out. One of the chief sources of difficulty is that the soil units must be established and grouped or classified before they have been sufficiently studied and therefore, mistakes are

made and revision of earlier work is constantly called for. In short, the classification of soils is an evolutionary process and as knowledge increases changes become imperative and confusion is likely to accompany change. This situation is not peculiar to soil science, but I understand, troubles the botanist, the zoologist, the chemist, the physicist, and probably the workers in every field of knowledge.

I assume that we are interested in the classification of land in Illinois from the standpoint of its use. The use of land is influenced by other factors in addition to those having to do with the character of the soils which make up the land. Economic and social factors cannot be neglected, however, many of these factors are intangible and changeable and some of them may lack the significance ascribed to them by the specialists in the respective fields. It seems that there is need for a clear-cut analysis of the economic and social factors, presumably involved in land use, as to their significance and stability. It is only in this way that we can avoid beclouding the picture by our failure to distinguish between significant factors and those which lack significance and between those which are relatively stable and those which are so unstable as to be incapable of evaluation.

With this brief mention of the factors involved in land classification, other than soil factors, we will pass at once to the soil factors.

Soil units or soil individuals, often called soil types, have come into being because each soil is the product of the environment under which it was developed and environments differ within very short distances. The environmental factors are parent material, atmospheric climate, native vegetation, topography and underdrainage.

The parent materials of the soils in Illinois are almost entirely glacial in origin. Large areas in the state are blanketed by a wind-blown deposit known as loess which is of glacial origin. The loess varies in thickness from a mere film in the east central and northeastern parts of the state to many feet in thickness adjacent to the Illinois, Mississippi, Ohio, and Wabash rivers. It varies in geological age from Sangamon to post-Wisconsin. These variations in thickness and in age are potent causes of differences in the soils developed from the loess. In the east-central and northeastern parts of the state where the glacial drift is the parent material of the soils of the region, the character of the drift becomes of great importance. The drift in certain sections of this region is highly impervious resulting in shallow, relatively poor soils. In other localities in the same region it is excessively gravelly and stony. Soils developed from drift of this character are likely to be droughty. A third type of drift contains enough sand, gravel, and pebbles to insure sufficient permeability to water and plant roots and yet not enough to be objectionable. Soils developed from this type of drift rank well in agricultural value.

Alluvial sediments deposited in bottom lands, terraces, and outwash plains cover a large total area in the state and comprise a third parent material of significance in influencing soil character.

Climate, the second factor mentioned as important in influencing soil character, is relatively less important in a single state than in a large region. However, in Illinois the rainfall varies from about 35 inches in the extreme north to 43 inches in the extreme south and the growing season varies from about 150 days in the extreme north to 190 in the south. Differences in rainfall and temperature of this magnitude operating through long periods of time are reflected in easily recognizable soil differences of great importance in land use.

Native vegetation, the third factor mentioned, is recognized as having important relationships to soil character. In a humid, temperate climate, forest growth always results in organic matter and nitrogen depletion and in accelerated weathering. Forest soils are, therefore, recognized to be inferior to grass land soils in producing capacity and in lasting qualities.

Topography, the fourth factor mentioned, is of primary importance in influencing soil character because of its relation to rate of removal of soil material by erosion and to the development of an impervious clay pan subsoil. Slopes in Illinois in excess of about 3 per cent are subject to injurious erosion. The severity of erosion increases rapidly with increase in slope though there is no universal correlation between severity of erosion and per cent slope because of variation in resistance to erosion shown by different soils. No force is now more active in destroying the soils of Illinois than erosion.

Underdrainage, the fifth and last factor mentioned has had far reaching influence in determining the character of our soils. Excessively slow natural underdrainage has given us impervious clay pan subsoils while excessively rapid natural underdrainage has given us leachy, droughty soils. The recognition of these two conditions is essential in land use studies.

One other factor, that of age or stage of development, should not be overlooked in considering our soils from the standpoint of use. Soils developed in a humid, temperate climate are doomed to depletion because the predominant movement of water is downward carrying with it the loosely held plant nutrients. It is for this reason that in evaluating soils for use purposes, their age or stage of development is an important consideration. With the elapse of time, Illinois soils formed on nearly level surfaces develop an impervious clay pan and soils developed on rolling surfaces become leached and if sufficiently rolling are destroyed by erosion. This is a gloomy picture and it should be said that much can be done to retard these processes. It remains true, however, that soils pass

through a life cycle just as certainly as does a human being and that in our environment the ultimate end of all soils is decreased producing capacity.

An effort has been made in the foregoing to point out the necessity for recognizing and dealing with soil individuals when thinking of land use. The farmer does not till the soils of a county or of a township but rather the soils on a farm. To use his soil or soils to the best advantage he must recognize the capacity and characteristics of each soil with which he is dealing.

There are in Illinois something over two hundred soil types now recognized. These soils have been rated in a scale of from one to ten based on producing capacity. In this scale soils rated one are the highest producers and those rated ten are the lowest. This rating constitutes a soil classification based on producing capacity. With it soil maps showing any desired degree of detail can be constructed provided detailed soil maps are available which show the soil types rated.

Several state maps which may be considered land use maps have been constructed. None of these maps make use of the capacity for production rating and therefore, can serve only as guides to regions where certain types of farming or land use may be feasible. The first of these state maps was constructed in 1927, revised in 1929, and is now in need of a second revision. This map shows the soils of the state in 16 groups and while the capacity for production rating is not shown on the map it can easily be applied to it. A second map classifies the state on the basis of the severity of erosion. It will be noted that 9 per cent of the state is subject to destructive erosion and is suitable only for timber, that 8.5 per cent is subject to severe erosion and is suitable only for timber, permanent pasture or orchard, that 36.0 per cent is subject to harmful erosion but is general crop land and that 46.5 per cent is not subject to erosion if farmed intelligently. A third map has recently been constructed for the State Planning Commission, and it will be noted that this map is based on adaptation with little attention being given to relative producing capacity. This map shows that 65.5 per cent of the state is adapted to general farming, 11.5 per cent to pasture or orchard, 10.4 per cent to red top, pasture or meadow and 12.6 per cent to timber only.

Further progress in making available in the form of a state map the large amount of information contained on the detailed county soil maps will involve making use of the capacity to produce rating as well as the adaptation of the various soil types. By grouping the soil types a strictly land use map can be constructed which, if supplemented by the county soil maps, will serve a useful purpose as a guide for individuals in the use of land and as a basis upon which state and Federal agencies can build comprehensive and long-time plans for land use.

OUR SOIL EROSION MENACE

BY

F. A. FISHER

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When we read of a flood and its damages our thoughts are always at the wrong end of the story. We begin to wonder how to protect that flooded area by dikes, levees, dredging and straightening channels. It is a rare occasion if anyone ever thinks of it from how to stop the flood at its source. Maybe this spring we should turn the picture around and think of dust storms. Either one has the same general treatment. Why not reverse the engineer's ideas and go back up the stream to the source of this water and plan by reforestation and revegetation to hold these rains where they fall and let more of the water down through our subsoil and have clear trickling streams feeding the rivers the year around in place of a flood of muddy water every time it rains?

The daily papers always tell us of the damages done by these floods, the crops destroyed, the livestock drowned, the bridges washed out, and the buildings floated away. They never tell of the farmers' loss at the source of the floods in the millions of dollars worth of plant food and soils eroded away. They never tell of how we are rapidly making of our people a nation of subsoil farmers; how unrestrained soil erosion is rapidly building a new public domain in America, an empire of impoverished worn-out soil; land stripped of its rich surface and gullied beyond redemption. You have seen the national erosion toll figures quoted in dozens of magazines, but let me requote so we can readily get the picture before us.

1) An area in the United States the size of the State of Illinois—35,000,000 acres is already so badly gullied and eroded it is doubtful if it can ever be reclaimed.

2) One hundred twenty-five million acres or one third of our remaining good soil in the United States is being sheet eroded so rapidly it will soon be to the subsoil farmer stage. Then gullying starts readily. You can see thousands of such acres here in central Illinois—those yellow gravelly spots appearing on the slopes and tops of the little knolls in our good black soil fields.

3) We lose annually by water run-off 21 times the plant food taken out in crops.

4) Fully 75 per cent of the cultivated land in the United States is subject to some degree of impoverishing erosion when used for clean cultivated crops. One half of this is subject to serious erosion.

5) Our state as shown by the state soil survey map, shows approximately 50 per cent of our soils subject to some degree of harmful erosion. Fifteen per cent of this is now at the serious gullying stage.

6) On the first 1200 acres surveyed in our erosion area, 45 per cent of it showed the surface 6 to 12 inches already washed off, and on 10 per cent the top loessial deposit of 40 inches gone completely. Remember this has happened in a new country where the first plow was used in 1825.

7) The Mississippi River dumps annually 428,715,000 tons of soil at its mouth. This is the equivalent of 2½ townships of soil to a depth of four feet, or the annual destruction of 360 quarter section farms. Farmers operating these farms stripped of their fertility have but the slimmest opportunity to make a satisfactory living, whether prices go up or down.

We have been preaching and worrying about wearing our soils out by continuous cropping and putting nothing back. Hundreds of textbooks have been written on this subject. If I am informed rightly to date no textbooks have been written on soil erosion and only a very few definite erosion study stations set up. I believe we have eleven such fields under the supervision of the United States Department of Agriculture, and I doubt if many here ever heard of them.

America's original wealth, her natural resources, were so vast it is little wonder we started in to be wasteful, destroying some of the world's greatest hardwood forests and celebrating by community log-rollings, burning up these logs to get rid of them. We let lumber companies cut off timbers and not replace them, making $5,000,000 profits while as a result of this, $50,000,000 damages was done to the property down stream due to flood waters from above. Our land seemed to be limitless so as one field was cleared and it washed away, we abandoned it, and cleared another. That policy has come to an end, and we find ourselves today facing the opposite direction in trying to teach our farm people the value of conservation in place of devastation. Our farm people have gone too much on the theory that erosion is a natural process that cannot be avoided.

May I here give you a few brief illustrations of our lax national policy on land utilization. First take the Navajo Indian reservation, with an area of sixteen million acres; fifty years ago we had about 8,000 Indians on the reservation, with only a small amount of livestock. Today we have 45,000 Indians with over one million sheep and goats. Their

animal population has grown so rapidly that the grasses and shrubs are kept eaten into the ground and we have no natural cover to hold the soils in place following rain or wind. The Indians are seeing this problem and giving up a large per cent of their livestock.

Along the Rio Grande area is a small canyon 40 miles long through which flows the Puerco River; the soil was mapped a few years ago as a good alluvial soil. After a heavy flood last year almost the entire valley was covered by 1 to 3 feet of sand and sandy loam. Lives were lost, millions of dollars of damage done to personal property. Mr. H. H. Bennett, Director of Soil Erosion Service, investigated the watershed and found the grasses and undergrowth had been so completely eaten off that erosion was easily started and it was impossible to find an area where the original topsoil remained. We people reading that story missed the main point. We saw the property destroyed but never gave a minute's thought to the land destroyed in the two locations: first, the surface in the upland washed away and secondly, the good alluvial bottom-land covered with sand, the fine rich soil being carried out into the larger streams.

We were all startled by the story of the flood in California last December at which time 60 people were killed and millions of dollars worth of property was damaged, roads destroyed, bridges washed out, etc. But very few of us ever heard why this happened, so let me tell the story. Thanksgiving Day in one valley a fire destroyed 5,000 acres of timber with its ground cover. When the December rains came with a waterfall of 12 to 18 inches in thirty-six hours there was no undergrowth or ground cover to hold this moisture—only a hard soil that absorbed water slowly so off went millions of tons of soil and caused the damage. The truth then, is that it was the fire that caused the flood because adjoining valleys where there had been no fire, but which received the same rainfall had no floods. The forestry service in California burned over a small area to note the effect of rains. A 12-inch rain fell and on the burned over area the run-off amounted to 300 buckets of water, on the unburned area of the same size, only eight buckets. I could go on giving these illustrations and not have to go West. We have it here in Illinois. Our greed for crops has forced the breaking up of rolling timbers and pastures and after two or three good crops the soil washes off rapidly and we see through Illinois these gravelly surface soils all gullied and now so poor they can hardly be put back into grasses.

The business man is interested in this program, for he wants to build lakes on our small streams for city water supplies and pleasure resorts. These once constructed at a large expense are filling up rapidly by the careless farming methods at the headwater of all the branches of these streams. Lake Decatur is an example of this rapid silting in. The Government has asked Mr. Bennett, the Director of Soil Erosion Service

in the Department of the Interior, to help them develop a revegetation program to keep all this soil from washing into the large lake back of Boulder Dam. The engineers underestimated the silting in rate. Please remember this, don't think of it only as a lake saver, but a soil conservation program.

I mentioned earlier in this paper that through the United States we have eleven Soil Erosion Control stations. I want to quote a little from the Missouri Station, so you will know better what these stations are teaching us about the soil losses we have been talking about.

We have been told that it takes Mother Nature at least 400 years to build an inch of this good, black soil, or about 3,000 years to build our top 7 inches. At the Missouri station the plots with an average slope of 4 per cent are located on a good, black soil. They are arranged so they catch all the run-off of water and soil from these plots. Plot No. 1 is cultivated each season but no crop planted. Under these conditions the water run-off and soil erosion is so great that in 24 years the surface 7 inches of soil would be washed off.

Plot No. 2 is planted to continuous corn. With this plan it would take only 50 years to lose the top 7 inches. This is just the lifetime of the average farmer.

On Plot No. 3 is planted a rotation of corn, wheat and clover; here it would take 350 years to lose the surface 7 inches.

Plot No. 4 in continuous bluegrass, lost soil at the rate of 3500 years for the top 7 inches. In other words, man's methods of farming speeds up rapidly Nature's power to erode soils.

At these fields soil losses are being checked by applying different soil treatments and the growing of legumes. They are also studying checking of soil losses by different methods of farming as strip cropping, contour farming, and terracing.

With a National President who is interested in this great problem of conserving our National resources, soil erosion has come to the front. People are reading about its effects, applying it to land values, and above all asking for help to stop this menace. With this in mind, appropriations were made from P. W. A. funds to develop throughout the United States demonstrational areas on Soil Erosion. Illinois was given one of these projects. The first thought was that maybe it should be in extreme southern Illinois where the menace no doubt is greater. The representatives from Washington, though, disapproved of this plan, saying they were not interested here in Illinois in a reclamation project of poor lands but wanted to go up into the higher-valued lands of the corn belt and put on a conservation project. In this they are right, for it is more important to conserve what good soils we have left than to try to reclaim soils that will cost more to reclaim than their probable production worth.

The area selected for Illinois is located on the Bloomington Moraine in McLean County between Bloomington and Gibson City. The south and east sides of the area are the lower edge of the moraine. The area comprises about 140,000 acres with approximately 700 farm operating units. Our program, built up hurriedly and without the guiding experience of former work, had to take shape as we went along and we have had to make many changes as we progressed.

The first step was a series of educational meetings among the farmers as to just what we were planning to do. As a demonstration we have asked the farmer to furnish the land and we will furnish the other materials necessary for the project. The farmer signs an agreement to go along with us for five years. We have divided our program into four parts.

1) A farm management survey to get information on the cropping system practiced on that farm, and to use as a guide in building a cropping system that will put life back into the soil and using farming practices to conserve soil.

2) A soil survey based on original soil type as nature left the soil and the degree of erosion that has taken place to date.

3) A gully control program to put in erosion control structures such as brush dams, wire check dams, grass bag dams, basket dams, tree plantings and sod strips.

4) A terracing program on slopes averaging from 3 to 7 per cent gradient. This later being done only on farms where the land owner lives or a tenant who has been there for some time and is likely to stay several more years.

You are not interested in the details of this program but what we hope to do is to apply all practical known methods to farms in this area to check our soils from washing away. After all, what can be more important to the future of our nation than the conserving of our soils? May I close with the following little verse, author unknown.

EROSION

Hordes of gullies now remind us
We should build our lands to stay,
And, departing, leave behind us
Fields that have not washed away;
When our boys assume the mortgage
On the land that's had our toil,
They'll not have to ask the question
"Here's the farm, but WHERE'S the SOIL?

UTILIZATION OF ILLINOIS LANDS FOR FORESTRY, WILD LIFE AND RECREATION

BY

T. H. FRISON

Chief, Illinois State Natural History Survey, Urbana, Illinois

It is indeed significant and indicative of changing conditions when a subject such as utilization of Illinois lands for forestry, wild life, and recreation creeps into a State Academy symposium. This gathering is assembled, too, in an area of Illinois where until the last few years there has been a relentless and uninterrupted trend towards the removal of the last vestiges of our native woodlands and wild life, and recreation has been essentially something apart and different from the joy of seeing, sensing, and getting into contact with those great living natural resources with which our state was endowed by nature.

There is now, however, much evidence that our awakening to the need of land in Illinois for forests, wild life and recreation is directly correlated with economic factors. So vital are these factors, even in an agricultural area which has been referred to as the bread basket of the world, that we are now being forced to revise the evaluation of our natural and renewable organic resources, pay heed to their preservation, and formulate sound and intelligent policies for their utilization.

Previous speakers in this symposium have called attention to some of the evidence which is causing people everywhere to start thinking of land utilization in its broadest sense. This evidence has been portrayed to you today in word pictures of the great differences which now exist in the soils of Illinois lands and which govern their degree of usefulness and values, the projects now under way to stop further serious losses of desirable soils through various types of erosion, and how the standard of living is reflected by natural resources. A great American, Benjamin Franklin, once said that it does not take long to see the bottom of the barrel if we are always taking out and never putting any thing back in. His words fit the situation in Illinois today and I am glad to say we are beginning to take heed as shown by this symposium. From the standpoint of forests and the larger forms of wild life, however, we have waited until the bottom of the barrel has begun to show.

The utilization of Illinois lands for forests, wild life and recreation is not the simple problem it may seem at first glance. A stream or a wild life area is a complex biological unit of sundry and different or-

ganisms. Each is affected by the others and in turn affects the whole. Everyone acquainted with conservation activities throughout the country in past years knows that enormous sums of money have been practically wasted by both public and private agencies in behalf of increasing fishing or hunting. Meanwhile, these essential wild life resources have steadily declined. The launching of programs for utilization of lands in Illinois or anywhere for forestry, wild life and recreation can share this same fate unless each and every program or project rests upon sound and impartial data. Even then, over a long period of time, there will inevitably be some shifting and readjustments from time to time if there are again periods of skyrocketing of prices and then sharp declines.

It is apparent to all who have had anything to do with serious planning for utilization of land for forestry, wild life and recreation that these three phases of utilization are usually directly interwoven or at least can be made to interlace. When we bring back large forested areas, wild life properly encouraged is likely to return to an abundance within the limits of the carrying range, and recreation will and can easily be made to follow. I believe that planning for land utilization in Illinois should have a program broad enough to take in everyone and every type of interest.

There is no doubt that conservation activities in the past have often suffered severely from cliques of well-meaning individuals who could not get together; each pulling for a special type of conservation versus the type or types desired by others. It is significant that within the last three months, and for the first time in this country's history, we have witnessed all brands, sizes, and shapes of conservation organizations backing President Roosevelt's Committee on Wild Life Restoration in their attempt to formulate a national wild life restoration program.

Far-sighted land utilization programs, like conservation in general, should and can be broad enough to take in the lover of our birds and wild flowers, the hunter, the fisherman, the picnicker, and the scientist. I have no sympathy with a program which at great public expense would develop extensive areas of renewable natural resources and then forever lock them up and deny the public who paid the bill its share of their wise utilization or enjoyment. Neither have I sympathy for those short-sighted groups or individuals who would ruthlessly exploit and ruin that which they did not build and that which they would not replace or renew. Each interest in proper land utilization, as in conservation, will greatly profit by united and concerted efforts.

Although I have stated that programs for increasing forests, wild life and recreation are interwoven, each different area must be consider-

ed in the final analysis as a special problem with due regard to its former natural state and its present niche in our social and economic order. The Cook County Forest Preserves because of proximity to a large metropolitan area necessarily have heavier recreational demands than would an area of similar extent in the Ozarkian uplift of southern Illinois. In one locality the emphasis must be forestry, in another place upland game, still other areas must cater to migratory waterfowl, fish, recreation, etc. Nearly always, however, one or two major objects can be advanced at the same time. As an example of this I can cite an area near Danville, Illinois, where there is a large acreage of strip-mined land which is now virtually useless. This, if properly developed, could support an abundance of fish and game of a certain type, produce a good stand of a certain type of timber, provide a haven for wild flowers and our feathered friends, and serve as a recreational center for a large number of people. The Illinois River Valley presents another problem, particularly from the standpoint of barriers in the way of restoration. Southern Illinois is mainly a forestry problem with recreational and game interests thrown in.

Studies published by our Survey about eight years ago state that the original forest area in Illinois was over fifteen million acres with an average stand of 4,280 board feet per acre. This had shriveled by 1926 to an area of about three million acres with an average stand of about 1,000 board feet. As the land was cleared of its trees, it was devoted mostly to the raising of corn, wheat, oats, hay and other annual agricultural crops. We are now learning, because of crop yields, erosion, and other results, that the entire removal of the forests on part of this land was a mistake from the standpoint of a long-time land utilization program. Much of this land is truly submarginal and suited only to the production of a forest crop. This is particularly true of large areas in western, south-central and extreme southern Illinois.

A sound program of land utilization for this state should aim at the eventual reestablishment of forests on approximately six million acres of land now waste, cleared or semi-cleared. The present state forest of over 3,000 acres is only a drop in the bucket and the area should be rapidly and steadily increased. The establishment within the last twelve months of two National Forest units in Southern Illinois of potentially 600,000 acres was a big step in the right direction. This acquisition program must not be allowed to lag and in time this area will act as a stimulant to our state forest program. County forest programs and private forestry should not be forgotten and merit our attention. Even our tax laws are in need of revision to open the way for proper utilization of Illinois land through reforestation by private landowners. Proper legislation must be a plank in our utilization program.

All early accounts of Illinois indicate that nature was exceedingly provident in bestowing our geographical area with bounteous wild life resources. An early English traveler once chronicled that "the wealth of Illinois lies in its land." He might well have added "and in its inland waters." The early struggles of the Indians for possession of the Illinois country, the existence of large Indian communities on the banks of the Illinois River and the largest mound builder community in the world near the Mississippi River were not accidents. They are a sure indication of an early abundance of fish and game—resources so essential to primitive peoples.

Reliable statistics concerning yields and values of game and fish are not plentiful. We do know, however, that in 1908 the Illinois River was worth about one dollar per linear foot on the basis of prices paid for fish to the commercial fisherman and about two dollars per linear foot on the basis of prices paid for fish by consumers. The estimates of commercial fishing at this time give us a production in this river from eighteen million to twenty-four million pounds. Together with the income resulting from trapping, duck hunting, sport fishing and general recreation, the Illinois River Valley represented a great source of income to our state and from products, too, for which at the present time there is no overproduction. Although the Illinois River territory accounted for a large amount of our wild life resources, it was not the whole story and the entire state with its forests, prairies, lakes and rivers had its contributions to offer.

A land utilization plan for Illinois must further the improvement of wild life resources. In 1932, with about 350,000 licensed hook-and-line fisherman in this state, we had about one acre of water—good, bad or indifferent—for each fisherman. When we include the number of persons not required to have licenses, such as minors and farm owners, there was probably less than one-half acre of water for each fisherman. It is suprising with this limited water area that our disciples of Izaak Walton were able to average about two pounds of fish for the year. When it comes to upland game, with the possible exception of rabbits, the situation is certainly no better. In 1930-31 there were nearly 350,000 hunting licenses issued in this state. This means that there was about 118 acres of cleared or uncleared land for each hunter. The migratory waterfowl situation is well known to most of you. Much data have been assembled by the U. S. Biological Survey which indicate this resource is in real danger.

The stage of ruthless exploitation of our wild life resources is practically over except for isolated instances; due mainly to the present status and scarcity of wild life. Legislation as a means of saving wild life is not all that many suppose. In spite of laws we have witnessed a steady decline in certain essential wild life resources. Legislation

has been helpful and is still needed but we must look to other methods to achieve increase in abundance of the more desirable species of fish and game. The pushing of land utilization programs from the standpoint of forests, aided by the furthering of proper fire protection, cover and feed areas, will surpass incubation methods and be much less expensive. Probably if all the money received from the issuance of game licenses could be devoted to rearing quail under hatchery conditions there would not be one-fifth of a quail per licensed hunter. Cover, feed, and fire protection are the big factors and these have a chance in an intelligent land utilization program, even in the heart of the corn belt territory.

The recovery of bottomlands from the clutches of drainage districts —land that in most places cannot carry the present cost of its overhead— needs to be made an integral and major part of our Illinois land utilization program. Fish hatcheries serve useful purposes, particularly as educational exhibits and as a ready source of stock, but the idea that they alone will bring back good fishing in the type of waters peculiar to Illinois and over large areas is something of a fairy tale. Hatcheries rearing fish suitable for our waters are at best only about five times as productive as good natural areas of like acreage and character. With about 75 acres of water area in state hatcheries it is not difficult to understand that the total output can have but a negligible effect on our approximately 500 square miles of water area. The cost of stepping up fish production through hatcheries so that it would exert a real and tangible effect upon our total fish resources would be exorbitant. The solution of our fishery problem lies mainly in recapture through wise land utilization of those areas taken away from our rivers, particularly the Illinois River, by drainage districts and promotional schemes, and the increase in our state of impounded waters wherever possible. Clean streams and forested river margins are necessary parts of this program. Illinois has at best but a small water acreage as compared with other states and we need every acre of it. At the present time, at least, we apparently do not need so much corn and oats. This water area, also, could be the means of stopping the migration from our borders of many millions of dollars spent elsewhere.

I am not going to take your time recounting ways and means of human beings finding recreation on Illinois lands. Forests, fish, and game all can be translated into terms of recreation. It is for recreation that most people hunt, fish, or visit our woodlands. Although we have a large body of licensed hunters and fishermen, we have a much greater number of people who need land for an opportunity to commune with nature, to stretch their legs and to shake off the dust and mental cobwebs invariably collected by humanity under the pressure of social and economic conditions. This need is becoming of increasing importance

and the issue must be met. It is folly to use our best lands for this purpose and equally so not to use our submarginal lands.

I can briefly summarize my ideas of a land utilization program for forestry, wild life and recreation for Illinois as follows:

(1) Reforestation of nearly six million acres of submarginal land through federal, state, county, or private agencies. Much of this area should be in southern Illinois, but smaller units for such a program are available in most sections of the state and must be utilized to accomplish the greatest good from the standpoint of recreational uses. Sand lands, of which we have about 75 square miles, should be included in the forestry program.

(2) Restoration in the interest of fish, game, forestry, and recreation to as natural or improved state as possible of much of the former floodplains and bottomland lakes of our river systems, particularly of the middle and lower Illinois River valley, and the impounding of new water areas wherever useful and practical. Clean waters are prerequisites to the fullest success of this program.

(3) The establishment of game and migratory waterfowl sanctuaries.

(4) Expansion of our state park system whereby all types of areas are included and sufficient acreage is involved to absorb recreational demands without endangering those bits of wild life or flora of special or peculiar interest to scientists and wild life lovers.

(5) Recreational development will follow, or can easily be made to follow the types of land utilization just outlined.

(6) Promotional schemes and attempts to unload on public agencies submarginal lands at exhorbitant prices must be avoided.

Submarginal land is in a sense waste land which, if carefully utilized, can be made productive of forests and wild life crops of which at present there is no overproduction. At the same time these areas can be used in a variety of ways to improve the mental and physical well-being of our citizens.

On top of this I would urge that all land utilization projects should be guided by scientifically acquired data of an impartial character. The data of this character which exists for Illinois today is largely the result of the activities over a period of many years of our State Scientific Surveys and the Illinois Agricultural Experiment Station. I know it has been a source of gratification to these organizations to observe the great increase in public interest and appreciation of the value of these data and to see years of patient labor—sometimes criticized by short-sighted individuals as of no practical value—blossom forth in a new radiance and utility. The Illinois Agricultural Experiment Station and the State Scientific Surveys are research and service organizations and are equipped to supply the leadership in the evaluation and scientific guidance of land utilization problems.

MEMOIRS

JESSE LOWE SMITH
1869-1934

Jesse Lowe Smith, superintendent of schools in District 107, Highland Park, Illinois, died in the Presbyterian Hospital, Chicago, April 21, 1934. The school year that was nearing its close at the time of his death was the thirty-second year of his services as an educator and leader in the life of the community.

He was born in Macon, Illinois, November 23, 1869. After graduation from De Pauw University, he taught in the public schools of Macon, Lexington, and Park Ridge, Illinois. In 1902 he commenced his administrative work in the school system of Highland Park.

In this community his sympathetic interest in worthy enterprises, and his ardor in progressive and creative movements led to multiplied calls for his services. He served for many years on the library board of the city, and took active part, also, in the work of the Highland Park Tree and Parkway commission. He was for some time a director of the North Shore Art League, and served in an advisory capacity in civic and educational enterprises in other North Shore communities. At the time of his death he was engaged in plans and activities in alleviating the problems of unemployment, and in C. W. A. enterprises.

Living in the profound conviction that man's usefulness, and to a large measure even his happiness are commensurate with his intellectual growth, Jesse Smith gave most unreservedly to any movement that promised intellectual upbuilding in his fellow man. He had the utmost sympathy for the forgotten man in the educational sense. In the round of activities engendered by this passion he was called upon to be one of the past presidents of the Chicago Geographic Society, a president of the Audubon Society, and for a long time a director of the Friends of our Native Landscape Society.

It is, however, through his radiant personality and his kindly sympathies that his influence will live the longest in the minds of his fellows and in his community. His extremely active and intense life was motivated by his friendship for people. He loved to take parties of friends and students into the woods and fields for observations, first-hand, and for fellowship. His teaching was effective and most successful, for he had the capacity to open the eyes of the unobserving, and to inspire and enthuse the minds of his auditors with an appreciation for the ways of Nature. His exuberance over the successful outcome of some quest for

new knowledge to be gained in outings of that kind was a thing most contagious. Even those physically weary with the tramping found themselves rejoicing that they were in at the finish.

And then, with characteristic self-effacement and humility, he was equally ready to go as a student where the role of an instructor was given to another. But on occasions of this kind, one found himself listening with interest to the appreciative questions and the apt comments of Jesse Smith, the student. And the range of interests and the depth of insight, unconsciously revealed, became items of inspiration to teacher and fellow students. His willingness to receive of the things he prized most highly made his capacity to give all the greater.

The highest tribute to the man, perhaps, can be utterly conveyed in the conviction retained by those who knew him. And that is, that time spent in the presence of Jesse Smith was time well spent, because one retains memories of a gentle spirit, a kindly and generous disposition, a loyal and understanding sympathy. And with those recollections in mind, the whole genius and inspiration of his life are best epitomized, no doubt, in a comment on that life made by a member of his own family—"Every day meant so much to him."

JOHN R. BALL.

OLIVER CUMMINGS FARRINGTON*
1864-1933

Born and pre-professionally educated in Maine, later studying at Yale under Dana and Penfield, where in 1891 he earned the Ph. D. degree, Oliver C. Farrington came west in 1894 after the Columbian Exposition to the position of Curator of Geology in the new Field Museum, which office he held to his death. He was both a charter and a life member in the Academy.

Farrington's bibliography includes more than 100 titles, many in mineralogy and geology largely in connection with Field Museum activities, a well-known semi-popular book on Gems (1903), and meteorite studies. These last are what secure his fame in science, not only for the two books which appeared in 1915, the semi-popular *Meteorites* and the large quarto memoir *Catalogue of the Meteorites of North America*, but also for the numerous original papers, among which are the description of the largest known stony meteorite, now in the Field Museum collection, and contributions on the composition, classification, and origin of these interesting members of the cometary family.

The excellence of the present geological collections at the Field Museum is in no small part due to the vision and ability of Farrington, who was also intrumental in securing the outstanding meteorite collection, the leading one as regards number of falls represented.

He is survived by his wife, Clara Bradley Farrington. Although diffident and retiring, his kindliness, tolerance, and humility made him loved of all those who came to know him. It was a great loss, both personal and scientific, that the heart trouble to which he finally succumbed was such a burden on him during his later years.

D. JEROME FISHER.

* A memorial of Dr. Farrington by S. K. Roy, to whom the writer is indebted for information, appeared in the Proceedings of the Geological Society of America for 1933, 193-209, 1934.